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P-78: Characteristics and Driving Scheme of Polymer-Stabilized Monostable FLCD Exhibiting Fast Response Time and High Contrast Ratio with Gray-Scale Capability

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Abstract

We have fabricated a zig-zag defect-free surface-stabilized ferroelectric liquid crystal display(SSFLCD) by using a newly developed polyimide(PI) alignment film and by adopting polymer stabilization with a polymer network with mesogenic side chains. The fabricated polymer -stabilized(PS) SSFLCD exhibits high contrast ratio (230:1) and fast response speed (τ=40μs) with perfect grayscale capability. The developed PI films were characterized by surface morphology study with an AFM and by switching characteristics of FLC cells. We suggest that the freedom of zig-zag defect of the SSFLC cells is attributed to the smoothness of the rubbed PI films. We have developed a new driving scheme for our monostable FLCD that has an asymmetric electrooptical characteristics. Further, we have developed a prototype experimental of field sequential full color LCD using our monostable FLCD.

Introduction

Ferroelectric liquid crystal displays (FLCDs) form the basis of a rapidly developing technology of significant potential impact in display applications, in particular, such as video image displays by taking advantage of their fast response speed. However, it is hard to fabricate a zig-zag defect-free FLCD that is capable of exhibiting high contrast ratio of over 100:1.

A new polyimide(PI) films has been synthesized by the reseach group of Nissan Chem. Ind. ; in a previous paper the present authors demonstrated a perfect black state of the SSFLCD fabricated using rubbed PI films owing to the zig-zag defect-free. Further we also demonstrated a superior electrooptical characteristics feature by monostability with fast response speed (τ=40μs). and high contrast ratio (230:1) with grayscale capability by adopting a polymer stabilization with photocurable monoacrylates with mesogenic side

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chains.[1] We suggest the physical models for the formation of zig-zag defect-free C2-uniform state and for the monostability. Further we will report a novel driving scheme for the asymmetric monostable electrooptical characteristics by devising a driving waveform; in addition to this, we will report a field sequential full color LCD using our monostable FLCD.

Experimental

(A) Fabrication of FLCD cells

We used a developed PI called RN1199 synthesized by the research group of Nissan Chem. Ind. The FLC material used was ZLI-4851-100 (Hoechst) whose relevant properties are shown on Table 1. The FLC, which was doped with 2wt% photocurable acrylate monomers with mesogenic side chains (UCL-001 Dainippon Ink and Chemicals), was injected into an empty cell whose inner substrate surfaces were parallel rubbed PI-RN1199 films. The filled cell was irradiated with UV light (365nm, 2mW/cm^2) for 30 seconds under the application of a monopolar electric field at a temperature where the FLC medium is in SmC* phase. In this way the FLC medium is polymer stabilized.

Table 1 Properties of ZLI-4851-100.

Properties	
Phase sequence	Cryst.(<-20)SmC*(67)--SmA(71)N*(76)Iso.[℃]
Spontaneous polarization	22.8nC/cm^2 (20 ℃)
Tilt angle	30.5° (20 ℃)
Switching time	38 μs(E=15V/μm, 20℃)

(B) Characteristics of polymer stabilized SSFLCD cells

Microscopic texture of aligned FLC was observed with a polarizing microscope and the electrooptical characteristics of the PS-SSFLCD cell was also measured with a conventional measuring system.

(C) Characterization of alignment films

Surface morphology of PI-RN1199 was observed with an AFM and switching currents were measured on FLC cells with PI-RN1199 films.

Characteristics of PS-SSFLCD

(A) Microscopic textures of PS-SSFLCD

First of all, a PS-SSFLCD fabricated in this research is zig-zag defect-free that results in perfect black (dark) state, which is shown in Fig. 1 together with a light state.

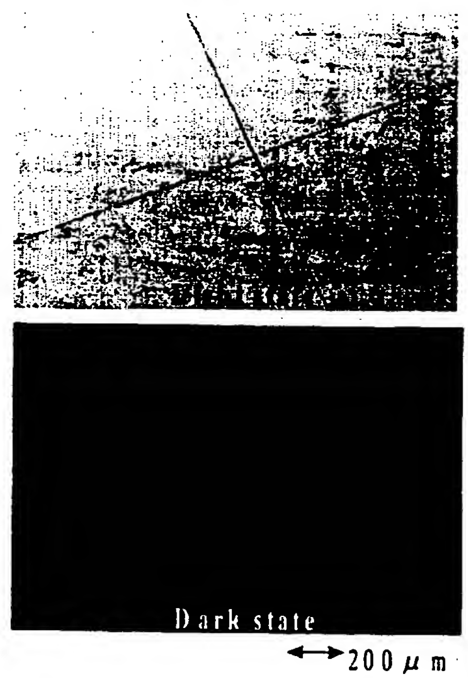

Figure 1 Microscopic textures of PS-SSFLCD with PI-RN1199 films.

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(B) Electrooptical characteristics of PS-SSFLCD

Fig. 2 demonstrates an example of electrooptical characteristics that shows the contrast ratio of 230:1 for V'; the characterisitics is asymmetric. Fig.3 shows the suggest potential energy vs. deflection angle of FLC molecules. The polymer netwoks with mesogenic side chains produce an anisotropy in the bulk region determined by the polarity of the voltage applied during UV photocure.

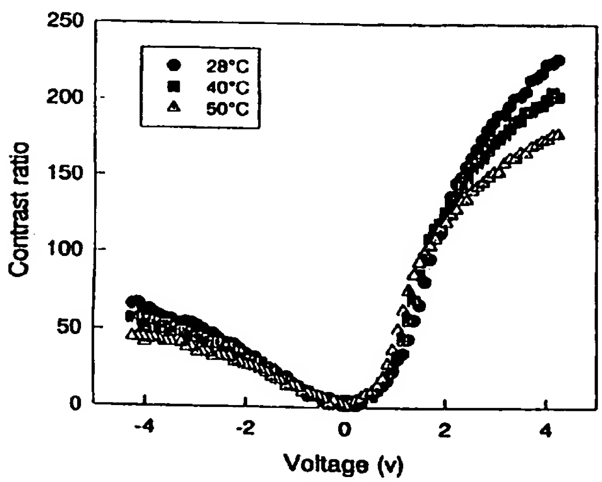

Figure 2 Contrast ratio vs. applied pulse voltage for the PS-SSFLCD

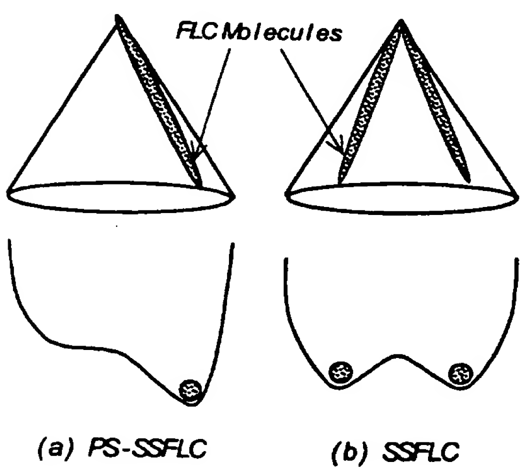

Figure 3 Potential energy model for (a) monostability and (b) bistability.

Characterization of PI-RN1199 film

(A) Surface morphology of PI-RN1199 film

We observed surface morphology of PI-RN1199 film with an AFM (SPI3700 Seiko Instr. Div.). The results show that the surface of rubbed PI-RN1199 film is much more smooth compared with a conventional PI, such as SE150 (Nissan Chem. Ind). From these results, we suggest that the formation of a zig-zag defect-free FLCD with C2-uniform state is attributable to the surface smoothness. The detailed results of this will be published elsewhere[2].

(B) Switching Current in FLC cell

Temporal switching current behaviour for triangular voltage waveform provides us with an information of depolarization electric field that degrades contrast ratio in a bistable FLCD. According to our investigation, in a bistable SSFLCD cell with PI-RN1199 exhibits a very good memory capability. This situation suggests that no effective depolarization field appears; the detailed results will be published elsewhere.[2]

Driving scheme for monostable FLCD

The electrooptical characteristics of our PS-SSFLCD is an asymmetric as shown in Fig. 2. A driving waveform that accommodates to this characteristics is devised as shown in Fig. 4. The waveform is an asymmetric pulse for V^+ and V^-, but the area of V times pulse period is kept to be the same. Fig. 5 demonstrates an average of optical response for V^+ and V^-

in the monostable FLCD which has the characteristics shown in Fig. 2. It is found that the case where $t_{v-}:t_{v+}=1:4$ results in the best electrooptical performance; the longer t_{v+} is, the higher the average of contrast ratio is.

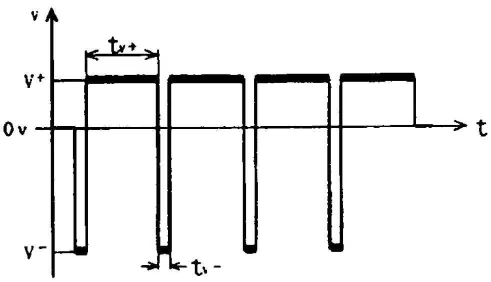

Figure 4 The driving waveform for monostable FLCD. ($V^+t_{v+}=V^-t_{v-}$)

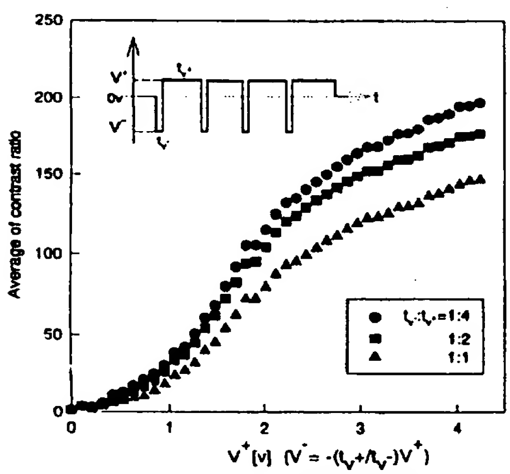

Figure 5 Average of contrast ratio vs. applied voltage for PS-SSFLCD.

Field sequential full color FLCD

Conventional color LCDs use color filters, instead of it the adoption of the field sequential approach allows us to fabricate an LCD with high luminance and high resolution. For obtaining a flicker free field sequential LCD, the frame rate for each of R, G, B color is 60 frames/second. The minimum response time of each pixel is 2ms for a static image. For displaying a moving video image, the response time must be at least 100μs. Our FLCD satisfies this condition. Timing chart for a field sequential color(FSC) LCD with SXGA specification using our PS-SSFLCD is shown in Fig. 6. Performance of a prototype model of FSC-LCD will be published elsewhere.

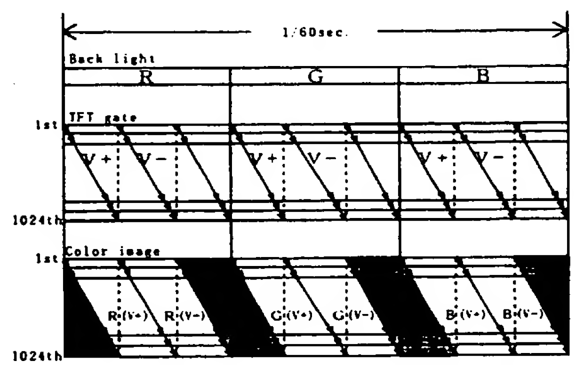

Figure 6 Timing chart for FSC-FLCD.

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